Article VI.—THE GANODONTA AND THEIR RELATIONSHIP TO THE EDENTATA.

By J. L. Wortman, M.D.

In a recent paper in this Bulletin I have called attention to a primitive suborder of the American Edentata, under the title of the Ganodonta.[1] Although the genera composing this group have long been known, yet the materials have up to the present been so imperfect and fragmentary as to preclude in a great measure any very exact knowledge of their true affinities. It has been only by the aid of a fortunate discovery of a fore limb of one of the species (*Psittacotherium multifragum*) in association with the lower jaws and upper teeth, that I have been enabled to interpret the somewhat fragmentary remains of the other genera and make out what I believe to be, not only their affinities to each other, but what is still more important, *to demonstrate* their genetic relationship to the later appearing American Edentata.

Touching the question of the relationship of certain of the forms, associated in the suborder Ganodonta, to the Edentata, it is proper to add that the idea has been suggested before, but no attempt has to my knowledge ever been made to establish the truth of such a proposition by direct proof.

Marsh, in his original description of *Stylinodon*, says,[2] "These specimens resemble in some respects the corresponding parts of the genus *Toxodon* Owen from the Quarternary of South America; but may, perhaps, have some more affinities with the Edentates."

He further adds in his address before the American Association for the Advancement of Science, August, 1877, the following: "The Edentate mammals have long been a puzzle to zoölogists, and up to the present time no clew to their affinities with other groups seems to have been detected. A comparison of the peculiar Eocene mammals which I have called the *Tillodontia*

[1] Vol. VIII, Art. xvi, pp. 259–262, Nov. 30, 1896. Also Science, Dec. 11, 1896, p. 865.
[2] Amer. Jour. Sci. and Arts, Vol. VII, May, 1874.

with the least specialized Edentates, brings to light many curious resemblances in the skull, teeth, skeleton and feet. These suggest relationship at least, and possibly we may yet find here the key to the Edentate genealogy. At present the Tillodonts are all from the lower and middle Eocene, while *Moropus*, the oldest Edentate genus, is found in the middle Miocene and one species in the lower Pliocene."

Cope originally held that his suborder Tæniodonta, which includes the two genera *Ectoganus* and *Calamodon*, was related to the Edentata, but later he came to an entirely different conclusion, based upon the determination of the enlarged teeth in the front of both upper and lower jaws. These teeth have always been considered by him to be incisors, and seeing that incisors are practically absent in the Edentata, he was compelled upon this view to abandon the idea of Edentate affinity. His latest position is contained in his article,[1] 'The Mechanical Causes of the Origin of the Dentition of the Rodentia,' in which he says: "I have regarded (Naturalist, 1884, and earlier) the Tæniodonta as the ancestors of the Edentata. The objection to this view is the supposed absence of inferior incisors in the latter. But the middle incisors are disappearing from the Tæniodonta, while the supposed canines of the lower jaw of *Megalonyx* and allies may be true incisors. This is rendered probable by the genus *Diadomus* of Ameghino, where the large canine-like teeth are found close together at the *symphysis mandibuli*, like the incisors of the Tæniodonta and Rodentia." He further adds, on page 4 of the same article, "*Psittacotherium* is, then, a generalized type, and is not far from, if not directly in line of, the ancestry of all Rodentia."

Dr. Max Schlosser in discussing the relationship of various forms of mammalian teeth, remarks:[2] "It is true that there are in the Eocene of North America certain forms, *Esthonyx*, *Calamodon*, *Psittacotherium*, which on the one side are evidently related to the Creodonts, *Onychodectes* and *Hemiganus*, and which, on the other hand, in so far as their tooth-form is concerned, can be regarded as the ancestors of, at least, a part of the

[1] Amer. Nat., Jan., 1888, p. 4, foot-note.
[2] Die Differenzeirung des Säugetier Gebisses. Biolog. Centralblatt, June, 1890, p. 252.

Edentates, to the extent that, in such a line, the formation of prismatic teeth out of the tritubercular and tuberculo-sectorial type can be traced. The real genetic relationship of these forms cannot up to date, however, be proven."

It will be further noted that the genera which I herewith associate in the suborder Ganodonta have been variously referred. Marsh placed *Stylinodon* in the Tillodontia; Cope has considered *Calamodon* and *Ectoganus* to represent a distinct group, Tæniodonta, at the same time placing *Psittacotherium* in the Tillodontia. In a like manner he has classified *Hemiganus*, *Onychodectes* and *Conoryctes* with the Credonta. Zittel has grouped them all into the Tillodontia together with *Tillotherium*, *Anchippodus* and *Esthonyx*.

Now, before any definite understanding of the mutual affinities of these genera can be had, it becomes imperative at the very outset to gain a clear and concise understanding of the group Tillodontia. The second point of vital importance is the correct determination of the incisor and canine dentition in the various genera. I will now attempt the elucidation of these two important questions.

Characters of the Tillodontia.

Regarding the first of these, the Tillodonts, I will say that they form a restricted, clearly-defined group composed, as we now know them, of the genera *Esthonyx*, *Anchippodus* and *Tillotherium*, extending in time from the base of the Wasatch to the upper Bridger Beds. They are characterized, especially in their latest and most highly developed representatives (*Tillotherium*), by the possession of an incisor dentition like that of the Rodentia, *viz.:* the great enlargement, limitation of the enamel to the anterior surface, and growth from persistent pulps, of the *second* pair of incisors in both jaws, together with more or less complete disappearance of the first and third pairs, and the gradual reduction in size of the canines. With these characters are associated large and powerful premaxillaries extending backwards upon the superior surface of the skull, between the maxillaries and nasals, almost to the frontals.

The group is further characterized by molars and premolars with short, completely enamel-covered crowns, with a distinctive tritubercular pattern in the upper, and a tuberculo-sectorial pattern in the lower jaw. The feet were provided with claws, well curved and rounded, without any evidence of fissures.

The group Tillodontia, as we now understand it, begins in the lower Wasatch, in the genus *Esthonyx*, in which all the specialized characters of the later *Tillotherium* are clearly and distinctly foreshadowed.[1] In *Esthonyx* there are three pairs of incisors in the lower jaw, and two pairs in the upper jaw, and it is of the greatest importance to note that the third or outer pair of incisors in the lower jaw is extremely small and just upon the point of disappearing ; that the second pair in the lower jaw is considerably enlarged, having great elongation of the enamel on the anterior face, and a narrow band upon the posterior face from which the enamel is absent. The first or middle pair in the lower jaw is considerably reduced in size. The lower canines are of good size, slightly exceeding the enlarged second pair of incisors.

In the upper jaw the first or middle pair of incisors is completely absent, no trace of them having been found as yet in any specimen, but the second pair is much enlarged, and there is a narrow vertical band on the posterior or lingual face in which the enamel fails. The third pair of incisors is of good size, but considerably smaller than the second pair. The canines of the upper jaw are somewhat smaller, relatively, than the corresponding teeth below, but yet show comparatively little tendency to degeneration. None of the teeth of the species of *Esthonyx* grew from persistent pulps, although the pulp cavities of the enlarged second pair of incisors in both upper and lower jaws remained open for a considerable time after the animal reached maturity.

From the Wasatch species of *Esthonyx* we pass to the Wind River representative *Esthonyx* (?) *acutidens* Cope, in which is to be remarked some important modifications in the direction of the still later or Bridger *Tillotherium*. All that is known of the Wind River form is the greater part of a superior dentition of one side. In this species it is important to note that the size has increased

[1] I pointed out this fact more than ten years ago, but it appears to have been adopted by palæontologists without any credit. See 'Teeth of the Vertebrata,' American System of Dentition, Philad., 1886, p. 434.

considerably; the premolars are more complex than in the Wasatch species, the second pair of incisors is still more enlarged, and the third or outer pair of incisors and the canines are still further reduced. The lower jaw is not known, but it can, with almost absolute certainty, be predicted that when found it will show complete absence of the third or outer pair of incisors, a fact which, as we are accustomed to estimate genera, would take it out of the true genus *Esthonyx*. It is, indeed, just such a transitional form as we would reasonably expect to find in this transitional bed between the Wasatch and Bridger.

The next form in the series is *Anchippodus* (*Trogosus*), from the lower Bridger horizon of Wyoming, which is known from an imperfectly preserved lower jaw only. It is very nearly related to *Tillotherium*, the only difference being in the possession of a small vestigial pair of first incisors. The second pair is greatly enlarged, with the enamel limited to the anterior face, and grew from persistent pulps.

Lastly we come to the final term in the series, *Tillotherium*, from the upper horizon of the Bridger formation, and here we find that the incisor dentition has undergone a still further change in the loss of the first pair of incisors in the lower jaw. The dentition, therefore, is expressed in the formula I.$\frac{2}{1}$, C.$\frac{1}{1}$, Pm.$\frac{3}{3}$, M.$\frac{3}{3}$. Three species have been described by Marsh, *viz.*: *T. fodiens*, *T. minor* and *T. latidens*, all from the Bridger beds of Wyoming. The group appears to have either become extinct or migrated at this time, since no remains referable to it have been found in any later deposits in this country.

It will thus be seen, therefore, that the Tillodontia represents a distinct, closely-connected phylum, reaching throughout the entire Wasatch, Wind River, and probably the greater part of the Bridger epochs. One of the main features of its evolution consisted in the production of a distinctly rodent-like incisor dentition, and the successive steps in that specialization form one of the most complete series to be found within the whole range of mammalian palæontology. Their earlier ancestry is at present completely unknown.[1]

[1] In this group we thus learn how the incisor dentition has been formed in the Rodentia, *viz.*: by the enlargement of the second pair in both jaws, and the discarding of the first and third pairs in all known forms, except the Lagomorphs, in which the first pair still remains.

The Incisor and Canine Dentition of the Ganodonta.

In one section of the Ganodonta there is as complete a succession of forms as there is in the Tillodontia. This section I have defined as the family Stylinodontidæ; it begins in the lowermost Puerco deposits and continues into the Bridger, where it also disappears. It is composed of the following genera: *Hemiganus*, lower Puerco; *Psittacotherium*, upper Puerco; *Calamodon*, Wasatch; *Stylinodon cylindrifer*, Wind River; and *Stylinodon mirus*, Bridger.

Now, *Hemiganus* occupies the same position in relation to the succeeding genera of the Stylinodontidæ as the genus *Esthonyx* does with reference to the succeeding Tillodontia, and the evidence of descent is equally conclusive. It is, therefore, of the utmost moment, if we wish to understand correctly the enlarged teeth in the front of the jaws of the later forms of the Ganadonta, that we interpret properly the condition in this incipient or parental form.

Fortunately in the single specimen of *Hemiganus otariidens* known, there is preserved a portion of the right maxillary, with the premaxillary attached, which serves to locate definitely the superior canine. The alveolar border of the premaxillary is damaged, so it is not certain whether it supported one or two incisors; there were probably two, but at all events the incisors were much smaller than the large powerful canine, which is preserved *in place*, and is seen to lie in the maxillary immediately behind the maxillo-premaxillary suture. The canine of the opposite side is also present in the specimen, and likewise has a portion of the maxillary attached to it.

The specimen also contains both rami of the mandible, but here again the alveolar border is broken so as not to show the number of the incisors. There are, however, two enlarged teeth preserved which are undoubtedly the lower canines. They fit with tolerable accuracy in the damaged sockets, and when the two rami are placed in apposition they occupy a position so as to oppose the superior canines closing in front of them. It is, moreover, probable that there were not more than two pairs of lower incisors, and possibly but a single pair. Be this as it may, however, they were much smaller than the canines.

It is demonstrated, therefore, beyond any possibility of doubt, that the enlarged teeth in the upper jaw are canines, and not incisors; it is almost equally certain that the enlarged teeth in the lower jaw are also canines and not incisors. The proof of this lies in the fact that there is evidence of seven teeth behind the enlarged tooth on one side of the jaw; no case is known

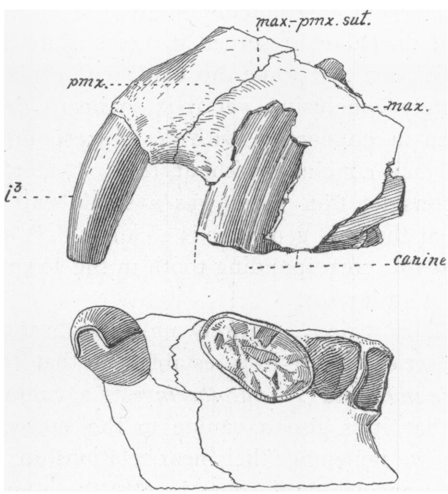


Fig. 1. Left premaxilla and part of maxilla of *Psittacotherium multifragum*. *I* 3, third or outer incisor; *c.*. canine; *pmx.*, premaxilla; *max.*, maxilla; *max.-pmx. sut.*, maxillo-premaxillary suture. (From Osborn and Scott's forthcoming book on American Fossil Mammals.)

among the mammalia in which an incisor becomes caniniform in the lower jaw to oppose a true canine in the upper jaw, although it not infrequently happens that a premolar is so modified.

From this lower Puerco representative we pass to the upper Puerco form, *Psittacotherium*, of which several complete lower jaws are known with all the teeth in place, together with a fragment of the upper jaw (No. 3414), including the entire premaxilla of the left side and a portion of the maxilla as far back as the second premolar (Fig. 1). This specimen fortunately contains an anterior tooth complete, and the root of the enlarged scalpriform tooth, which I have determined to be the superior canine. The specimen shows the free anterior border of the premaxilla, and, behind, a considerable diastema between the anterior tooth and the enlarged tooth behind. This space served to accommodate the enlarged tooth in the lower jaw, which is thus shown to have closed *in front* of the enlarged tooth above. The specimen unfortunately is of an old individual, and the maxillo-premaxillary suture is not very distinct. There are, however, distinctive appearances of a sutural line *in front of the enlarged tooth, and no traces whatever behind it*, as would undoubtedly be found in the considerable part of the palate preserved, if it existed in this situation.

It will thus be seen that while the evidence in this case is not in itself absolutely conclusive, yet it is so nearly demonstrative that when taken in connection with the corresponding teeth of *Hemiganus* we may conclude without fear of error that in the genus under consideration there was a single pair of superior incisors, and that the enlarged tooth is a canine. It would, therefore, follow that the corresponding tooth in the lower jaw is also a canine and not an incisor.

The premaxillary region is entirely unknown in the succeeding genera of this series, but if it is established that this enlarged tooth in *Hemiganus* and *Psittacotherium* is a canine, then it is quite certain that it is also a canine in the succeeding forms, especially when we remember their near relationship.

I have thus considered at some length the question of the determination of these teeth, because, as noted above, upon it depends a striking resemblance or a fundamental difference between them and the Edentata.

TABLE OF DISTRIBUTION OF THE GANODONTA IN TIME.

	Lower Puerco. 500 feet.	Upper Puerco. (Torrejon Beds.) 300 feet.	Wasatch. 2000 feet.	Wind River. 800 feet.	Bridger. 2000 feet.
STYLINODONTIDÆ.					
Hemiganus	...1 sp.				
Psittacotherium	....	...1 sp.			
Calamodon	....	....	..3 (?) sp.		
Stylinodon	....	....	....	...1 sp.	
Stylinodon	....	....	....	....	...1 sp.
CONORYCTIDÆ.					
Onychodectes	...2 sp.				
Conoryctes	....	...1 sp.			

THE MUTUAL RELATIONSHIP OF THE GENERA OF THE STYLINODONTIDÆ.

Hemiganus otariidens Cope.

We come next to examine the characters of the separate members of this assemblage of genera, and determine if possible in what way they are related to each other. The first one to be considered is *Hemiganus otariidens*[1] Cope. The genus was origin-

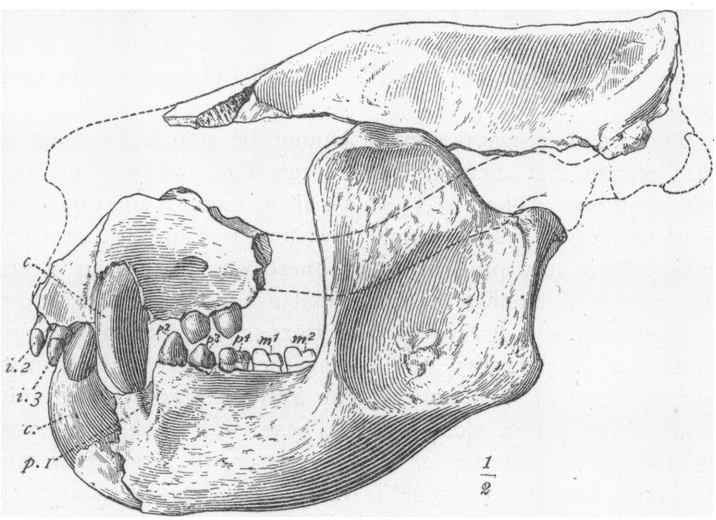


Fig. 2. Side view of skull of *Hemiganus otariidens.*

ally established upon an 'incisor' (=canine) tooth, and one species, *H. vultuosus*,[2] referred to it. Later an extensive description of a fragmentary skeleton of *H. otariidens* was published by Cope.[3] It is now evident from a careful examination of the specimens that *H. vultuosus* was founded upon a canine of *Psittacotherium multifragum* Cope, and must therefore be discarded. This leaves but a single species, represented by a single specimen, to represent the genus. It is important to note, in the first place, that it comes from the lowermost Puerco Beds, and is therefore the earliest

[1] Amer. Nat., 1885, p. 492.
[2] Amer. Nat., 1882, p. 831.
[3] Proc. Amer. Philos. Soc., July 20, 1888, pp. 311, 316.

member of the group, appearing, as it were, at the very beginning of the Tertiary epoch.

It will be impossible for me to add anything to Cope's excellent description, and I will content myself merely with a statement of the principal characters as shown by this fragmentary skeleton. In the skull (Fig. 2), of which a considerable part is preserved, the face is short, the sagittal crest is long and not very prominent, the lower jaw is short, deep and robust, with a greatly enlarged coronoid and a pronounced angle. The tooth-line passes to the inside and slightly behind the root of the coronoid, so that the last molar is partly concealed in a side view; the condyle is situated unusually high above the tooth-line.

The complete dental formula cannot be stated at present, but it is certain that there were four premolars and three molars in the lower jaw. There was also a pair of canines and one or two pairs of incisors. In the upper jaw there was at least one pair of incisors and very probably two; there was also a pair of large and powerful canines; the upper molar dentition is unknown.

In structure several isolated incisors show a long tapering root closed at its extremity, and having the enamel limited to the anterior face of the crown. The lower canines also exhibit a long tapering root closed at the base, and having the enamel limited to the anterior of face of the crown. Just how much this limitation of the enamel is due to wear, however, is not easy to say; it is more than probable that in a perfectly unworn young tooth, the entire crown is covered with enamel, but upon the posterior surface it is very thin and is soon worn away. The superior canine shows complete investment of the crown with enamel, although the covering upon the posterior portion of the crown is very thin. Of the premolars, two of the inferior ones (3d and 4th) are in place, together with the first molar. The third premolar consists of a principal cone with a slight cingulum, situated internal and posterior to the principal element of the crown, while in the fourth the internal cusp is larger and more posteriorly situated. It is highly probable that this posterior cusp is the incipient heel, the greater development of which would produce the posterior part of the true molar.

There are three lower molars preserved, the crowns of which are so much worn as to obscure considerably the pattern of the grinding surface; it can be stated, however, that it is composed of the usual four cusps which go to make up the quadratubercular crown. The four cusps were apparently fused into two transverse crests, the posterior of which is much the lower. The anterior cusp of the trigon is persistently absent, and there is much evidence of the fact that the molars did not pass through the typical 'tuberculo-sectorial' stage to reach the quadratubercular form. The superior molars are entirely unknown. All the molars of the lower jaw had well-developed roots with divided fangs.

It is a fact worthy of note, to which Cope has called attention, that the superior surface of the premaxillary is marked by a suture throughout its entire extent. This would indicate that the snout was, in some degree at least, tubular. The only similar condition that I have met with in the mammalia is that of the Armadillo, in which the nasals cover in the premaxillæ throughout their entire extent above.

A number of cervical vertebræ are represented by their centra, which are remarkable for their great transverse diameter in comparison with their antero-posterior dimension, as in the living Armadillos. The arches are not preserved, so it is impossible to determine their characters.

Of the fore limb the proximal parts of both ulnæ, a nearly complete radius, a lunar, the metapodial of the second digit, and a terminal phalanx, are represented in the specimen. The proximal end of the ulna shows a marked resemblance to that of the Gravigrada, especially *Mylodon robustus*, the olecranon being relatively short and the sigmoid portion for articulation with the humerus wide. The radius is short and robust, with a well-excavated head and an ulnar articulation which permitted free pronation and supination of the manus. It increases in diameter distally, and in its ridges and surfaces resembles both that of *Mylodon* and *Megalonyx*.

The lunar (Fig. 11) is free, presenting a convex proximal facet for the radius, a posterior extended portion, a cup-shaped facet for the head of the magnum, and lateral facets for the scaphoid and cuneiform ; its proportions and relations to the surrounding bones of the carpus are very similar to those of the corresponding bone of *Mylodon robustus*.

The metapodial of the index (Fig. 3) or second digit[1] is remarkable for its brevity ; it shows a fore and aft grooved articular facet for the trapezoid, and facets upon either side for the articulation of the first and third metapodials. The meta-

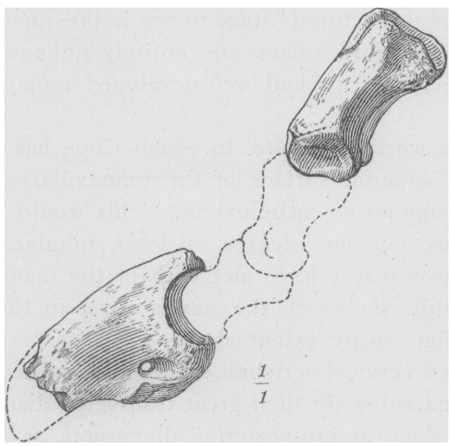


Fig. 3. Second metacarpal and ungual phalanx of *Hemiganus otariidens*.

podial keel is but faintly indicated, and is confined wholly to the palmar aspect of the distal facet.

The single ungual phalanx (Fig. 3) is proportionally very large, exceeding the second metapodial in length ; it is compressed and high, with a marked dorsal curvature. The articular surface for the second phalanx is deeply excavated, having a median vertical ridge, and a backwardly prolonged overhanging upper portion. The whole facet describes almost a semicircle. The subungual process is large, and is perforated by a considerable foramen.

Of the hind limb only the proximal two-thirds of a femur and a complete tibia are known. The femur is a short, stout bone

[1] Cope has determined this metapodial to be a metatarsal, but there can be little doubt that it not only belongs to the fore foot but that it is the second metacarpal.

with a short, globular, sessile head, which does not rise above the great trochanter; the whole bone is markedly flattened from before backwards; there is a strong lesser trochanter and a weak third trochanter. The general shape of the bone recalls at a glance the femur of the Edentates, especially the Ground Sloths.

The tibia,[1] in comparison with the femur, is short and small. The proximal portion is crushed so as to obscure the form of the head of the bone, but the distal end is well preserved. The distal trochlea for articulation with the astragalus is not very well grooved, but yet the grooves are better developed than in any other Puerco mammal of corresponding age. The internal malleolus is well developed. The whole character of this part of the tibia resembles the corresponding part of this bone in the Armadillo.

Psittacotherium[2] *Cope.*

Remains of this genus have been found, so far, only in the upper Puerco (Torrejon Beds), and, as the stratum in which it is found is separated vertically from that of *Hemiganus* by from four to five hundred feet of sediment, one would naturally look for important modifications. Cope referred this genus to the Tillodontia, and has described three species as belonging to it, *viz.: P. multifragum*, *P. megalodus*, and *P. aspasiæ*. After a careful study of all the materials now known, I am convinced that there is but a single species, *P. multifragum*. *P. megalodus* was founded upon a fragment of lower jaw of a rather large individual of *P. multifragum*, but the difference in size between it and some of the later specimens of the latter is so very slight that it cannot be regarded as a specific modification. On the other hand, *P. aspasiæ* was based upon a jaw fragment of a young individual in which the teeth were just being erupted. A second specimen of similar nature was referred to it, but until some more important differences are shown to exist, the species cannot be regarded as well established. I think it much more likely that both specimens are examples of immature individuals of *P. multifragum*, which would account for their small size.

[1] Cope makes out that this bone, of which there are two pieces, pertains to both sides, the head to the left and the distal half to the right side. When the matrix was removed, and the two ends fitted together, they were found to make a complete bone of the left side.

[2] Amer. Nat., 1882, p. 156.

Of the materials now extant there are no less than three nearly perfect lower jaws, together with numerous fragments of others. In one specimen (No. 754) a complete lower jaw and a part of the skull are represented; in another (No. 2456) the lower jaw, the upper teeth of one side, and a good part of the fore limb, are preserved; in numerous others there are fragments of upper and lower jaws, teeth and a few bones.

In the skull (Fig. 4), the facial portion is seen to be short and deep, the sagittal crest low and inconspicuous, and there is but a faint indication of postorbital processes upon the frontals. The anterior root of the zygoma is situated well forward; it has a

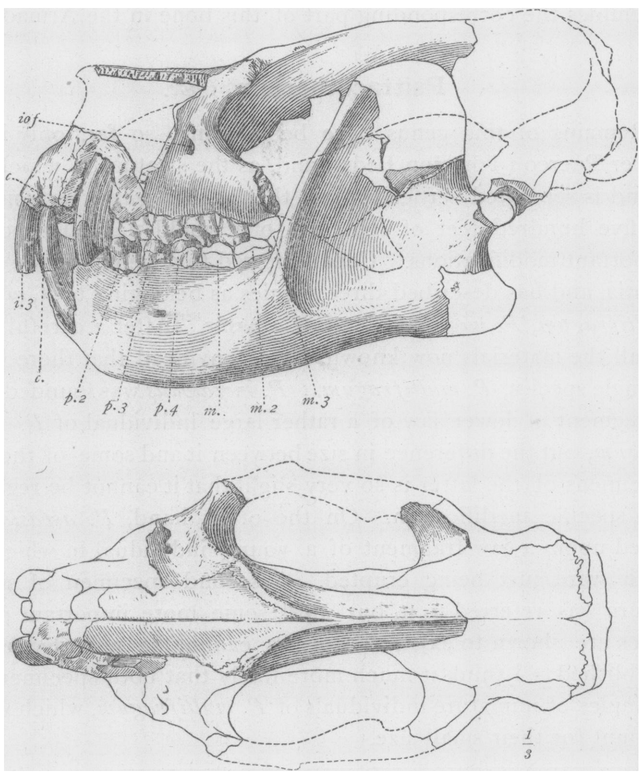


Fig. 4. Side and top views of skull of *Psittacotherium multifragum*. The outline of the lower jaw is completed after a perfect specimen, and the premaxilla of another specimen, the one represented in Fig. 1, has been used in the drawing.

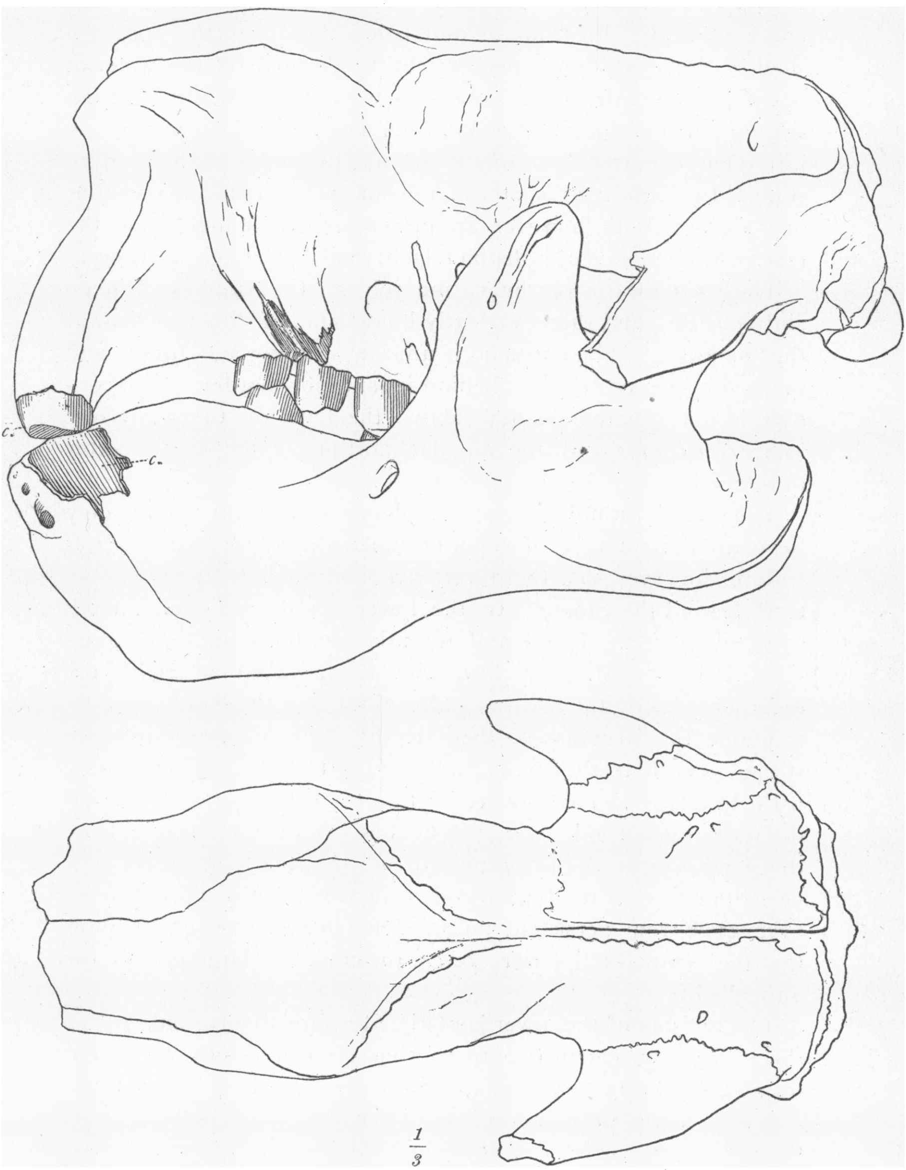


Fig. 5. Top and side views of the skull of *Megalonyx jeffersoni*. (After Leidy.)

considerable vertical depth and projects outwards, downwards, and backwards. In front of and below the zygomatic root is a shallow fossa, at the upper extremity of which is the anterior opening of the infraorbital canal, which is double. Leidy describes two foramina in this situation in *Megalonyx* (Fig. 5), and it is not an infrequent occurrence for this foramen to be double in the modern sloth. In *Psittacotherium* the main canal is below and the smaller one above. Both, however, are placed unusually high upon the face. No evidence of a distinct lachrymal foramen is to be seen.

The lower jaw is short, heavy and robust; the symphysis is deep and powerful, and there was early bony union of the two rami of the mandible. The coronoid is unusually strong and broad, and the tooth line passes well behind its anterior border. The condyle is not situated so high above the level of the tooth-line as in *Hemiganus*, and the angular portion of the jaw is better developed.

The dental formula is not completely known, the discrepancy being in the number of superior molars and premolars. It is certain, however, that there were five, and possibly there were six teeth behind the canine. In the lower jaw there are nine teeth upon either side. The dental formula can therefore be written: I.$\frac{1}{1}$, C.$\frac{1}{1}$, Pm.$\frac{3(?)}{4}$, M.$\frac{3(?)}{3}$. I have already discussed at length the determination of the incisors and canines, and there only remains to notice the structure of these teeth. The upper incisors are strong, curved teeth, deeply implanted in the premaxillary bones, with the anterior face covered with a thick layer of enamel, and the posterior portion having the dentine exposed. It results from this arrangement of the dentinal tissues that the tooth wears to a chisel point, as in the typical rodent incisor. They did not, however, grow from persistent pulps, although some specimens show that the dentinal pulps were active throughout a large part of the animal's life.

The incisors of the lower jaw (Fig. 6) are relatively smaller. In the younger specimens the entire crown is covered with enamel, but owing to its thinness and small extent upon the posterior surface, it is soon worn away, leaving an external enamel covering only; the tooth then wears into the typical chisel point. They likewise were not of persistent growth.

The canines are large, powerful, curved teeth, being deeply imbedded in the maxillary bones; the anterior surface is covered with a thick layer of enamel, but the posterior surface is devoid of any enamel. The canines did not grow from persistent pulps, but the cavities remained open and the pulps were active long after the animal was adult.

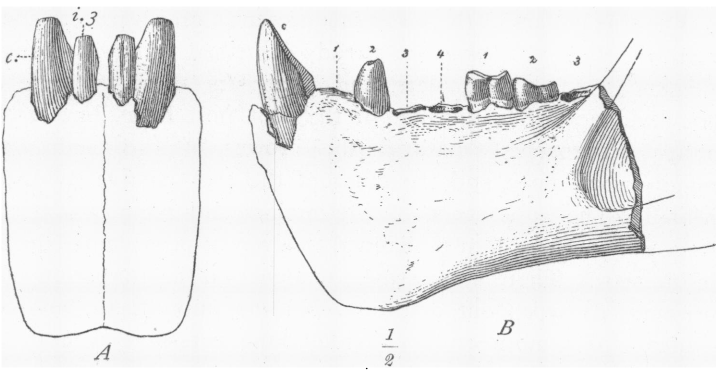


Fig. 6. Front and side view of the jaw of *Psittacotherium multifragum.* (From Osborn and Scott's forthcoming book.)

It frequently happens that the crowns of the molars and premolars are so much worn that the average specimen does not give one any clue to their pattern, but there are, fortunately, a few specimens in the collection from which a tolerable idea of the crown pattern can be had. This applies, however, only to the lower teeth, that of the upper teeth being totally unknown.

In one specimen (No. 3413) of a lower jaw (Fig. 7), the second premolar and the first and second molars are preserved in place, and the crowns are sufficiently unworn to permit of a determination of their structure. The second premolar displays two conical cusps placed at right angles to the long axis of the jaw; of these the external or labial cusp is the larger, and has its apex bent slightly inward, giving to it a distinct hook-shaped appearance;

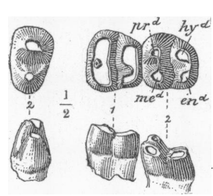


Fig. 7. Side and crown views of the second lower premolar, and the first and second lower molars of *Psittacotherium multifragum.* (From Osborn and Scott's forthcoming book.)

the internal or lingual cusp is smaller and stands vertical. There are in the collection a number of loose teeth of this pattern, and it is more than probable that they represent both superior and inferior premolars. It is, moreover, highly improbable that any of the premolars, with the possible exception of the fourth, reached a further stage of complication than that just described, *viz.:* the bicuspid stage.

The true molars of the lower jaw present a crown pattern identical with that of *Hemiganus* already described. In the younger specimens, in both molars and premolars, there is more or less evidence of a division of the root into fangs, but as the animal approached maturity the crowns of the teeth were rapidly worn away, and the fangs of the root completely disappeared. The appearance of the molars and premolars at this stage may perhaps best be likened to a row of pegs planted deeply in the jaw. There was a strong tendency to the formation of a prismatic or hypsodont dentition. In the upper teeth, however, evidence of a more or less divided fang persisted even in the oldest individuals.

Of the skeleton there is known only a part of a fore limb, including a complete ulna and radius, an unciform, lunar, cuneiform, magnum, the third and fourth metacarpals with their full complement of phalanges, together with the phalanges of the second digit more or less complete. To these should be added a few fragments of metapodials in the collection, which can now with certainty be identified as belonging to *Psittacotherium.*

The ulna (Figs. 8 and 9) of the most complete specimen (No. 2453) is somewhat damaged in the region of the olecranon and the articular surface for the humerus, but enough of it is preserved to determine its general characters. The bone is short and stout, exceeding the radius somewhat in size ; the shaft presents a strong lateral flattening, and an unusual antero-posterior depth ; it tapers but little from the sigmoid humeral articulation to its distal extremity, and the posterior edge has but a slight curvature.

The olecranon is not complete, but enough of it remains to show that it was of moderate length and but slightly incurved at its proximal end. The sigmoid articulation is spaciously excavated, with but a very prominent posterior edge, but there is evidence of a well-expanded inner lip to receive and support the broadened humeral surface with which it was articulated; beneath this lip there is a deep groove, as is usual in the mammalia. The articular surface for the head of the radius is

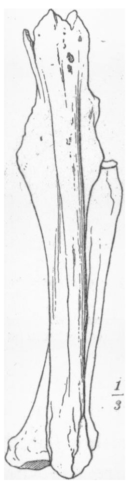


Fig. 8.

Fig. 9.

Fig. 10.

Fig. 8. Posterior view of ulna and radius of *Psittacotherium multifragum.*
Fig. 9. Side view and distal end view of ulna and radius of *Psittacotherium multifragum.*
Fig. 10. Side view of ulna and radius of *Megalonyx jeffersoni.* (After Leidy.)

concave from side to side, and receives accurately the head of this bone. The distal end of the ulna is but moderately expanded; it terminates distally in an obtuse styloid process, in front of which is the very oblique articular face looking downwards, outwards and forwards, for articulation with the cuneiform and pisiform. bones of the carpus.

The radius (Figs. 7 and 8) is short and robust, with a more or less cylindrical shaft, especially in its proximal half. The head is considerably expanded, but does not completely cover the anterior surface of the ulna. Its humeral articular surface is cup-shaped, and the facet for articulation with the ulna is convex from side to side, indicating that there was power of complete pronation and supination of the manus. The tubercle for the insertion of the

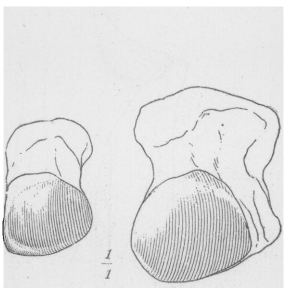


Fig. 11.

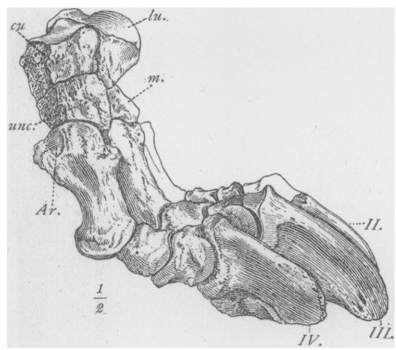


Fig. 12.

Fig. 11. Top view of the lunar of *Psittacotherium multifragum* (right) and *Hemiganus otariidens* (left).

Fig. 12. Side view of part of right fore foot of *Psittacotherium multifragum*: *lu.*, lunar; *cu.*, cuneiform; *unc.*, unciform; *m.*, magnum; *ar.*, articular surface for the fifth metacarpal.

biceps is situated high up on the ulnar aspect of the shaft, and in its distal third there is a well-marked and roughened ridge for the insertion of the pronator muscles. Distally, just before the shaft expands into its strong carpal extremity, it assumes a more or less quadrate outline in cross section. The carpal articular facet has a shallow cup-shaped form, but no dividing ridge separating the scaphoid from the lunar facets is apparent. Altogether the bone recalls that of *Megalonyx* (Fig. 10) or *Mylodon* in the most striking manner.

It is, however, in the organization of the manus (Figs. 12 and 13) that the most pronounced resemblances to the Edentates are seen. Indeed, if an anatomist had no other part of the skeleton than that of the foot to guide his judgment, and he should fail to detect a most striking similarity between it and that of the

Edentata, especially the Ground Sloths, he would not only lay himself open to the criticism of being lacking in the ordinary powers of observation and comparison, but would be suspected of placing the matter upon a basis other than that established by such a method.

The bones of the carpus preserved are the lunar, cuneiform, unciform, and the magnum; all of them are more or less dam-

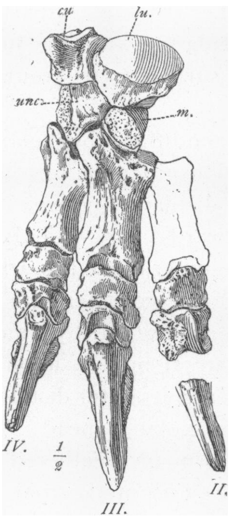


Fig. 13.

Fig. 14.

Fig. 13. Front view of same as Fig. 12. Lettering the same as in that figure.

Fig. 14. Front view of left fore foot of *Mylodon robustus* (after Owen). Lettering same as in last two figures.

aged, with the exception of the lunar, which is in an almost perfect state of preservation. This bone (Fig. 11), when viewed from above, shows an anterior globular articular surface for articulation with the radius, and a posterior more or less expanded portion behind; the bone shows a marked constriction where these two portions join. Upon the anterior or dorsal aspect the surface is imperfectly triangular, with the apex of the triangle directed downwards. Upon the radial side there is a convex articular surface for the scaphoid and on the ulnar side a double facet by which it joins the cuneiform above and the unciform below. Its lower surface shows a deeply excavated, oblong, cup-shaped cavity, which receives the head of the magnum, and in front of this a plain facet where it joins the anterior shelf-like projection of the magnum and a part of the scaphoid.

The *cuneiform* is so much damaged, particularly upon its ulnar side, as to preclude in a great measure the exact determination of its shape. Above, there are two facets by which it articulates with the pisiform behind, and the ulna in front. Upon its radial side there is a prominent lateral facet for articulation with the lunar. Below, it presents an excavated articular surface to the rounded head of the unciform.

The *unciform* is also in a damaged condition, but enough remains to satisfactorily determine its relationship to the surrounding bones. When looked at from above it displays a convex facet directed upwards, backwards and outwards for articulation with the cuneiform, and a slightly concave inner facet for articulation with the lunar. Below and to the radial side there are also two facets, imperfectly distinguished from each other, by which it joins the magnum above and the strong lateral process upon the ulnar side of the large third metacarpal. Upon its outer distal surface it offers a cup-shaped cavity to the globular head of the fourth metacarpal. The ulnar surface is so much weathered that it does not show an articular surface for the fifth metacarpal.

The *magnum* is relatively small and covers only a portion of the head of the third metacarpal. Its superior or proximal aspect shows a globular head, which occupies the posterior or palmar moiety of the bone, and an anterior shelf-like projection, which presents above a horizontal facet for articulation with the corresponding part of the lunar already mentioned. It articulates with the following bones : the lunar above, metacarpal III below, the unciform upon the ulnar side, and probably with both the scaphoid and trapezoid upon the radial side. Owing to the damaged condition of the bone, however, this latter statement cannot be verified.

Of the metacarpals there are present the third and the fourth in a tolerable state of preservation. *Metacarpal III* is remarkable for its relative shortness and robust character. Proximally it has a somewhat saddle-shaped articular surface, which rises much higher upon the ulnar than upon the radial side. This surface is occupied by the magnum. Upon the ulnar side of the proximal extremity is seen a large, somewhat lateral facet, by means of which it joins the unciform. Beneath this facet is another excavated articular surface of considerable size for union with the fourth metacarpal. Distally it is somewhat expanded, having a well-curved articular extremity, by means of which it joins the first phalanx. On the palmar aspect there is a weakly developed metapodial keel. The great extent of this facet indicates an unusual amount of flexion and extension of the phalanges.

Metacarpal IV is relatively longer and more slender than the third; its proximal surface is occupied by two facets of almost equal dimensions, both of which are directed upwards and inwards; the facet upon the radial side of the bone is but little convex, and abuts against the strong overhanging process on the ulnar side of M. III. The facet upon the ulnar side is much rounded, and is received into the cup-shaped distal extremity of the unciform. Upon its extreme outer or ulnar edge the head of the bone presents another shallow articular depression, which marks the point of articulation of M. V; this latter bone, however, is not preserved in the specimen under consideration.

The *proximal phalanges* are strikingly short, deep and broad; they are moderately excavated to receive the distal extremities of the metapodials, and at their distal ends are received into deep concavities of the second row (Fig. 14).

The *median phalanges* are likewise short and deep; their articulation with the claws is by means of a deeply grooved facet, which describes almost a semicircle.

The *terminal phalanges* are immense compressed claws without any trace of fissures at the ends; they show a considerable dorsal curvature, and on their palmar aspect are provided with powerful subungual processes, which indicates great strength for the flexor tendons. The articular surface of the claw is deeply excavated, and the dorsal portion of this articular surface overhangs the lower considerably. At the proximal extremity of the dorsal curvature is seen a roughened area, which served for the attachment of the extensor tendon. The length of the third claw exceeds that of the corresponding metapodial by considerable, but that of the fourth digit is about equal to its metapodial in length.

Among the specimens collected last summer by the Expedition, is one found by my assistant, Mr. Barnum Brown, in the Torrejon Beds or the Upper Puerco, consisting of two posterior dorsal, three lumbar and nine caudal vertebræ, together with a nearly complete pelvis. It was thought at first that these bones belonged to a large Creodont, probably a species of *Dissacus*, but they were so much broken that it was impossible to form any correct judgment of their true characters at the time of collection. Since they have been cleaned and mended it is now very evident that they do not belong to any known species of Creodont. The only other species occurring in this horizon to which they could be referred on account of size are *Pantolambda cavirictis* and *Psittacotherium multifragum*. A comparison with the corresponding bones of the smaller species of *Pantolambda* shows such great and fundamental differences that it is certain that the specimen in question does not belong to *Pantolambda*. There remains then only *Psittacotherium multifragum* to which the specimen can be referred, and if we can judge from the peculiar characters which these bones present, I think there can be no mistake in referring them to this species.

The most anterior *dorsal vertebra* (Fig. 15) preserved in the specimen I take to be the ante-penultimate, although it may have a more anterior position than this. At all events it is that dorsal in which the character of the zygapophyses changes abruptly from the flat to the involute form, and corresponds with the change in the direction of the neural spines, so noticeable in many forms, especially the Carnivora. This varies in different species, ranging from the third from the last to the fifth from the last of the dorsals. The centrum is somewhat depressed, and is slightly concave at either extremity. There are strong rib facets in the usual positions, showing that the ribs attached to this vertebra were articulated with the centrum in advance as well. The transverse processes are short and stout, and are occupied at their extremities by tubercular facets which look forwards and outwards. The anterior zygapophyses are flat and directed upwards,

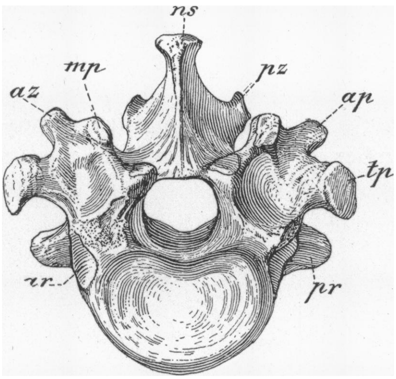


Fig. 15.

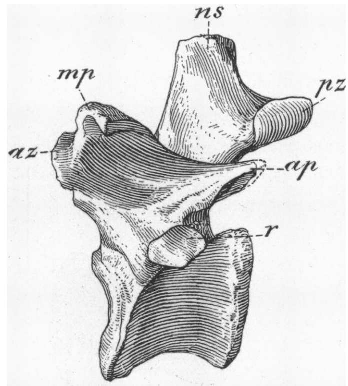


Fig. 16.

Fig. 15. Front view of a posterior dorsal of *Psittacotherium multifragum* : *ns.*, neural spine ; *mp.*, metapophysis ; *az.*, anterior zygapophysis ; *ar.*, anterior rib facet ; *pr.*, posterior rib facet ; *tp.*, transverse process ; *ap.*, anapophysis ; *pz.*, posterior zygapophysis.

Fig. 16. Side view of posterior dorsal of *Psittacotherium multifragum.* Lettering same as in last figure.

but the posterior zygapophyses present a strong outward convexity, and, as is usual in many forms of mammals, look downwards and outwards. There are well-developed metapophyses, as well as strong processes, which represent the anapophyses. The spine is low and moderately heavy, with an almost vertical direction.

The *last dorsal* (Fig. 16) is slightly larger than the one just described ; there are single rib facets at the junction of the pedicles with the centrum, and the anterior zygapophyses are deeply concave, with the posterior as strongly convex. There are well-developed metapophyses and anapophyses, the latter projecting well backward, beneath and to the outside of the succeeding zygapophyses.

The *lumbar vertebræ* are three in number, and as they were found locked in position with the last dorsal there is reason to believe that this is the formula forthis region of the spine. They increase slightly in size from before backward, have low spines, well-developed transverse processes and strongly involute zygapophyses. The complex articulations of the vertebræ of this region of the spine, so constant a feature of the later Edentata, are not present, but the presence of the strong, backwardly projecting anapophyses furnish a combination of structures which could have easily given rise to this peculiarity in the vertebral articulation.

Only a fragment of the *sacrum* is preserved, so that it is impossible to say anything of the number of vertebræ intering into its composition.

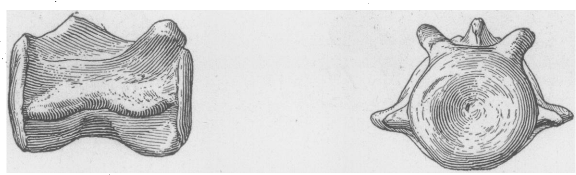


Fig. 17. Front and side view of ninth caudal of *Psittacotherium multifragum.*

Of the *caudal* vertebræ (Fig. 17) the first nine are preserved; the first is poorly preserved, being represented by the centrum only. The bodies of the remaining vertebræ are remarkable for their short, stout, cylindrical form, differing in this respect from those of all the cotemporary Creodonts, in which the bodies of the caudals are longer and much more slender. There are strong transverse processes on the first four or five, which are also provided with complete arches. Well-developed cheverons are present, as in the Gravigrada. Altogether the tail bones bear a marked resemblance to those of the Gravigrada.

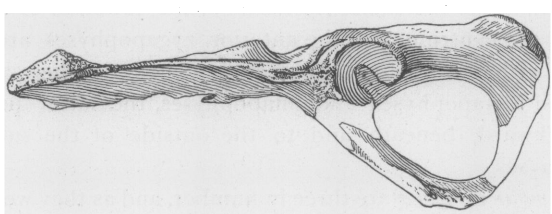


Fig. 18. Side view of pelvis of *Psittacotherium multifragum.* ⅔.

The *pelvis* (Figs. 18, 19 and 20) is so characteristic that it requires but a passing glance on the part of an anatomist at all familiar with the osteology of the Edentata to demonstrate its marked

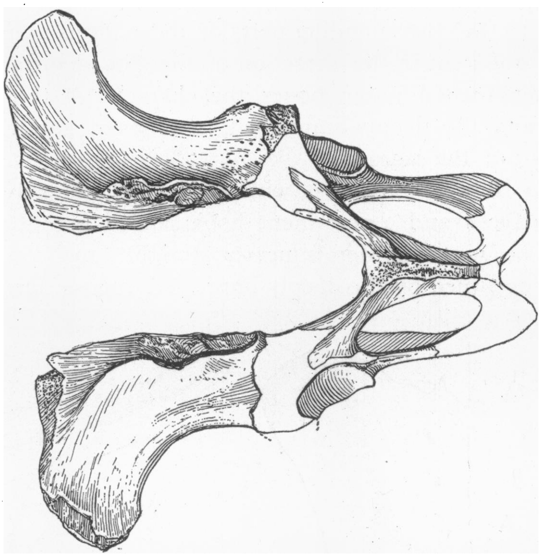


Fig. 19.

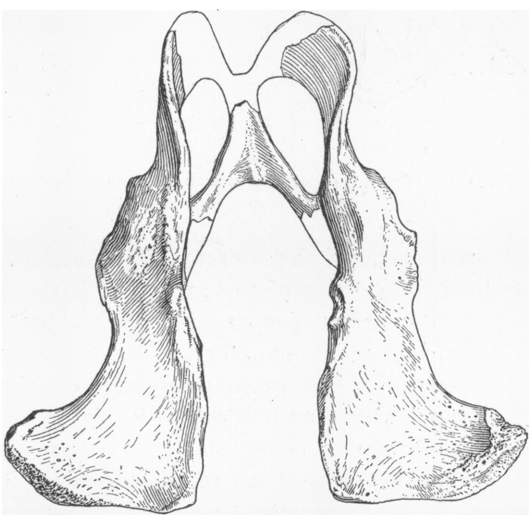


Fig. 20.

Fig. 19. Top view of pelvis of *Psittacotherium multifragum.* $\frac{2}{3}$.
Fig. 20. Ventral view of pelvis of *Psittacotherium multifragum.* $\frac{2}{3}$.

similarity to the corresponding parts of these forms ; this is most strikingly apparent in the direction of the gluteal surfaces of the ilia, the lengthened pubic bones, the character of the obturator foramen, and the deeply impressed, roughened surface for the attachment of the sacrum.

The *ilia* are well expanded, with nearly flat, dorsally directed gluteal surfaces and a prominent hook-shaped anterior superior spine. The inner border is nearly straight, and its posterior moiety is occupied by the deeply impressed rugose auricular sur-

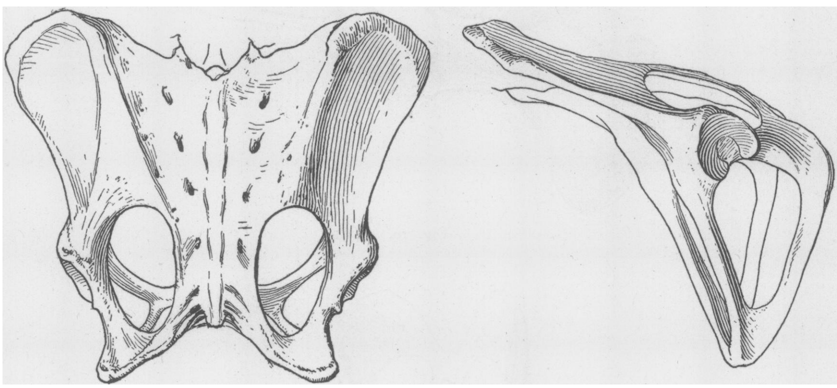


Fig. 21. Dorsal and side views of pelvis of modern Sloth, *Bradypus tridactylus.*

face for the attachment of the sacrum. This unusual rugosity foreshadows the coössification of the sacrum with the ilia, which is a marked and constant feature of all the later Edentates (Fig. 21). The acetabula are more or less damaged, but enough of them are preserved to indicate that they were wide and roomy.

The *ischia* are somewhat more elongated than in the modern Edentates, and there was no bony union between these bones and the sacrum, so that the sacro-sciatic foramen was not completed by bone hehind, as in all the later Edentates, but was closed by ligament, as in all the other mammalia.

The *pubic bones* are relatively long and slender, giving to this region of the pelvis an unusual vertical depth, a feature so highly characteristic of the later Edentates. They meet in a tolerably elongated symphysis, which is firmly united by bone. It results from the elongation of the pubic elements that the vertical diameter of the obturator foramen is much increased; in all the modern Edentates the vertical always greatly exceeds the antero-posterior diameter, but in the pelvis under consideration the two diameters are almost equal. It will thus be seen that in *Psittacotherium* the incipient changes leading to the Edentate peculiarity in this respect are already evident.

Comparison of Psittacotherium with Hemiganus.

It now remains to make an accurate comparison between these two important genera, and learn, if possible, in what their resemblances and differences consist. One of the most important facts to be borne in mind is their relative positions in time. *Hemiganus*, as before stated, comes exclusively from the lower Puerco Beds, while *Psittacotherium* is as distinctly confined to the upper Puerco (Torrejon Beds), the respective strata of the two being separated by several hundred feet.

The points of resemblance may be stated as follows: (1) The facial portion of the skull is short, and the sagittal crest is long and low; (2) the lower jaw is short, deep and massive, with a powerful symphysis, a broad high coronoid, and a prominent angle; (3) the condyle is placed high above the level of the tooth line, and the posterior termination of the tooth line passes behind the border of the coronoid; (4) the molar pattern in the lower jaw is identical in the two genera, and the premolar pattern of the one is clearly a derivative of the other; (5) the ulna and radius are very similar in the two forms; (6) the form and relationship of the lunar are identical; (7) the metapodials are short and stout, and (8) the terminal phalanges consist of greatly enlarged, compressed claws, identical in pattern in both.

The differences so far as we know them are slight, and consist, at best, in modifications of only generic significance. They are as follows: In *Hemiganus* the crown of the superior canine is completely invested in enamel, whereas in *Psittacotherium* it is limited to the anterior face of the tooth. In *Hemiganus* the roots of the lower molars possess distinct fangs, while in *Psittacotherium* the fangs become connate, especially in the older specimens, and there is little trace of them left. In *Hemiganus* again, the condyle is placed somewhat higher, and the angle of the jaw is less developed than in *Psittacotherium;* and lastly the lower premolars of *Hemiganus* possess but one principal cusp, with only a rudiment of the second; whereas in *Psittacotherium* the premolar crown is strongly bicuspidate.

It will thus be seen, and I hold that the demonstration is complete, that *Hemiganus* is the ancestor of *Psittacotherium*, the one having been derived directly from the other by descent.

Calamodon[1] *Cope.*

We come next to consider the Wasatch representative of this family, *Calamodon.* Three genera have been described from this horizon, *viz.: Ectoganus*[2] Cope, *Calamodon* Cope, and *Dryptodon*[3] Marsh. It is possible that two of these names are synonymous, *viz.: Calamodon* and *Dryptodon*,[4] and it is a matter of great uncertainty whether *Ectoganus* is distinct. According to Cope, the chief difference consists in the development of an oblique crest connecting the two cross crests in the lower molars, but as this distinction rests upon the evidence of a single much-worn tooth, it would seem the best course to regard it as synonymous until we have better material upon which to base a diagnosis. A species of the genus *Calamodon* has been described by Rütemeyer from Switzerland under the specific title of *C. europæus.* That it is a species of *Calamodon*, or some nearly related genus, there can be little doubt, but the specimen is so fragmentary that little more can be said of it.

Owing to the fragmentary condition of the materials it is well-nigh impossible to say just how many species should be recognized, but it is more than probable that there were at least two,

[1] U. S. Geolog. Surv. W. 100th M., p. 118, 1874.
[2] U. S. Geolog. Surv. W. 100th M., p. 116, 1874.
[3] Amer. Journ. Sci., Vol. XII, p. 403, 1876.
[4] A careful examination of Prof. Marsh's type specimen shows apparently some important differences from *Calamodon* in the arrangement of the enamel bands of the molars and premolars. Thus, in pm.$_{\overline{1}}$ of *Dryptodon* the crown is completely surrounded by enamel, whereas in *Calamodon* the enamel is interrupted. There seem to be other differences, but owing to the bad state of preservation of the teeth, they cannot be determined with certainty. The generic validity of *Dryptodon* cannot be regarded as fully established until we have better specimens; it appears, however, probable.

and possibly three, modifications which can be regarded as of specific value. The best known species is *C. simplex* Cope, from the Wasatch Beds of the Big Horn, which is represented by an almost complete pair of lower jaws, together with numerous other fragments of teeth. This species also occurs in the Wasatch of New Mexico in association with *C. arcamnœus*, and is further represented from this locality by fragments of the jaws and teeth, together with a fragmentary fore limb, including parts of the humerus, ulna, and radius, part of a metapodial, and a fragment of a terminal phalanx or claw.

The lower jaw (Figs. 22 and 23) displays practically the same characters in its general outline as those already described in

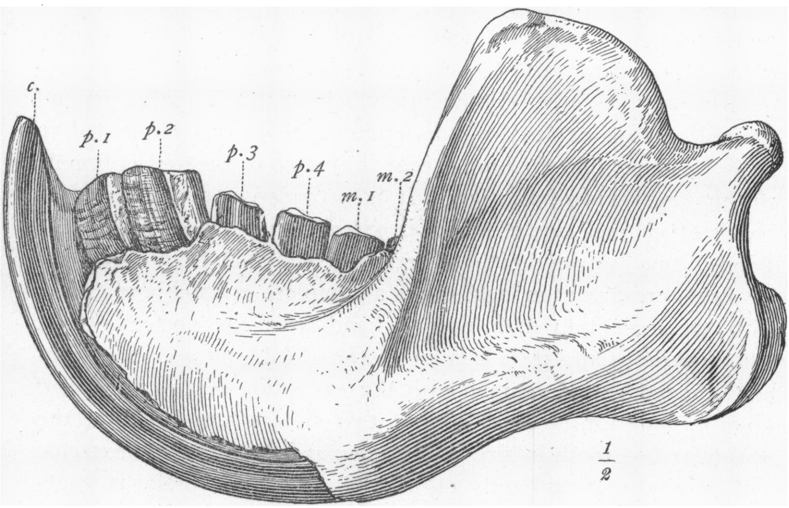


Fig. 22.

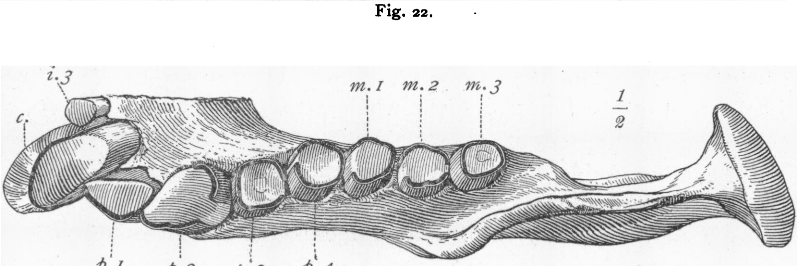


Fig. 23.

Fig. 22. Side view of lower jaw of *Calamodon simplex*.
Fig. 23. Top view of lower jaw of *Calamodon simplex*.

Psittacotherium. It is remarkably short, massive and deep, with a powerful coronoid and a prominent angle. The condyle is situated unusually high above the tooth line, the posterior termination of which passes well behind the anterior border of the coronoid, so as to completely obscure the last molar tooth and a good part of the second, in a side view of the ramus.

In the single complete specimen of the lower jaws known there is a pair of small incisors from which the enamel has completely disappeared, whether through wear or otherwise is not known.

The large curved scalpriform canine grew from a persistent pulp, and is covered with a thick layer of enamel upon its anterior face only. This tooth is followed, without the intervention of a diastema, by the first premolar, a relatively large tooth, imperfectly triangular in cross section, with the apex of the triangle directed outwards and covered with enamel upon its antero-external surface only. Immediately behind this is a large second premolar, more or less oval in cross section, and implanted in such a manner that the long axis of the crown is directed obliquely to the long axis of the jaw. It is provided with two vertical bands of enamel, one of which is external and the other internal. Behind this follows the third premolar, which has an imperfect quadrate cross section, and shows a complete enamel investment, with the exception of a narrow band upon its posterior face. The fourth premolar is similar to the third, and shows a complete investment of enamel, with the exception of a narrow band upon its anterior face. The first two molars are similar to the last-described tooth in size and shape, and have broad external and internal vertical bands of enamel. The last molar is somewhat smaller than the others, and its crown has a complete enamel investment. Neither the molars nor premolars grew from persistent pulps, but the roots are elongated, with scarcely any indication of the fangs, and the whole structure may be said to be decidedly hypsodont.

It is a noticeable feature in the teeth of this species that in addition to the vertical striation of the enamel surface, there is also a series of fine horizontal ridges, giving it a somewhat checkered appearance. It is also a fact worthy of note that in those situations where the enamel fails there is a thick deposit of cementum.

It is in very young specimens only that the pattern of the molar crown can be distinguished; in a perfectly unworn tooth (Fig. 24) the crown is seen to be made up of four subequal rounded cusps placed in the form of a square. The two anterior and posterior cusps are separated from each other by slight notches only, but the two anterior are separated from the two posterior cusps by a profound transverse valley,

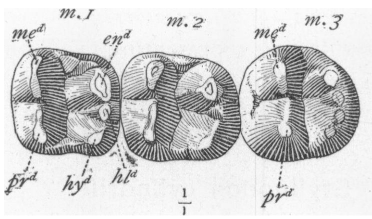


Fig. 24. Crown view of unworn lower molars of *Calamodon simplex*: *me^d.*, metaconid; *pr^d.*, protoconid; *hy^d.*, hypoconid; *hl^d.*, hypoconulid; *en^d.*, entoconid.

which reaches entirely across the crown. When the crown is a little worn it presents the appearance of two transverse crests, and when still more worn, so as to obliterate all traces of the crown pattern, there is a flat surface of dentine more or less completely surrounded by a ring of enamel.

The structure of the premolars has hitherto been completely unknown, but there is now contained an unworn crown of a second premolar; it is made up of a strong more or less hook-shaped external cusp and a subequal vertical inner cusp, thus recalling at a glance the structure of the second premolar already described in *Psittacotherium*. The structure of the crowns of the upper molars and premolars is quite unknown.

The fragment of humerus, as figured by Cope, indicates a short, stout bone, with a considerable distal expansion, and without doubt an entepicondylar foramen. The ulna and radius exhibit striking resemblance to that of *Psittacotherium* and *Hemiganus*, and like the corresponding bones in these genera, are devoid of a medullary cavity. Enough of a metacarpal is preserved to show that it also had a similar form to that of the last-named genera, as did also the terminal phalanx or claw.

The differences between *Calamodon* and *Psittacotherium*, while they are somewhat greater than they are between *Psittacotherium* and *Hemiganus*, are yet comparatively insignificant, and are just such further modifications in a given direction as one would reasonably look for in a later genus, more especially when it is remembered that these modifications were already clearly foreshadowed in *Psittacotherium* in its advance over *Hemiganus*. There cannot, therefore, be the slightest doubt that *Calamodon* is the direct descendant of *Psittacotherium*, from which it is separated in time by a deposit representing two hundred feet or more of vertical thickness.

Stylinodon cylindrifer *Cope.*

The next form in this family to be considered is the Wind River representative, *S. cylindrifer*. This species is known from only a single molar tooth, presumably of the upper jaw, together with a few fragments of a canine and some inconsiderable pieces of the skull. The molar tooth (Fig. 25) is remarkable for its long cylindriform pattern and the narrow vertical bands of enamel which have an external and an internal position with reference to the crown. The tooth differs from any known teeth of *Calamodon* in that it grew from a persistent pulp, and in having the vertical bands of enamel much narrower. The canine is represented by only a few fragments, but enough is preserved to determine the fact that it also grew from a persistent pulp, and had a thick anterior facing of enamel.

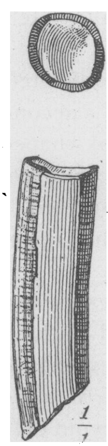


Fig. 25. Side and crown views of molar tooth of *Stylinodon cylindrifer*.

It is more than probable that when this species is more completely known it will be found to occupy an intermediate position between *Calamodon* and the Bridger *Stylinodon*, and will doubtless require the making of a new generic name. At present we can only provisionally refer it to the genus *Stylinodon*, with which it best agrees.

Stylinodon mirus *Marsh.*

While this paper was in course of preparation Prof. Marsh has published[1] a full account of the beautifully preserved remains of this species in his collection. The type consists of a fragment of the lower jaw, with three or four of the molar teeth in place, and indications of the alveoli of two more. The second specimen consists of all the cervical and first dorsal vertebræ, together with the first pair of ribs and sternum in position ; with these are associated a nearly complete fore limb, parts of the skull, jaw, and other fragments.

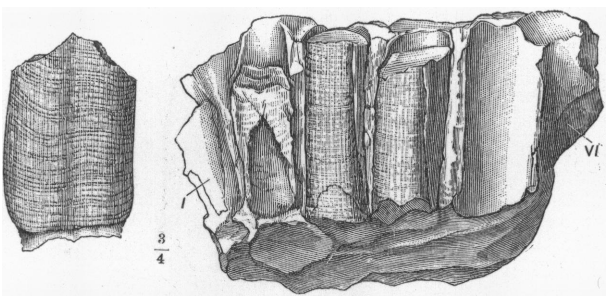


Fig. 26. Side view of lower jaw fragment (type) of *Stylinodon mirus.* (After Marsh.)

The type (Fig. 26) shows that the teeth were much elongated, rootless, of persistent growth, and provided with narrow vertical bands of enamel, which had an external and an internal position upon the molars and premolars, very similar to the single tooth of *S. cylindrifer* already described. Fragments of the large scalpriform canine indicate that it was faced with enamel, that it was of persistent growth, and was implanted in the jaw in the same manner as the corresponding tooth in *Calamodon* and *Psittacotherium.*

In the second specimen enough of the jaw is preserved to determine more fully its character. According to Prof. Marsh

[1] Am. Jour. Sci. (4), Vol. III, Feb., 1897, pp. 137-146.

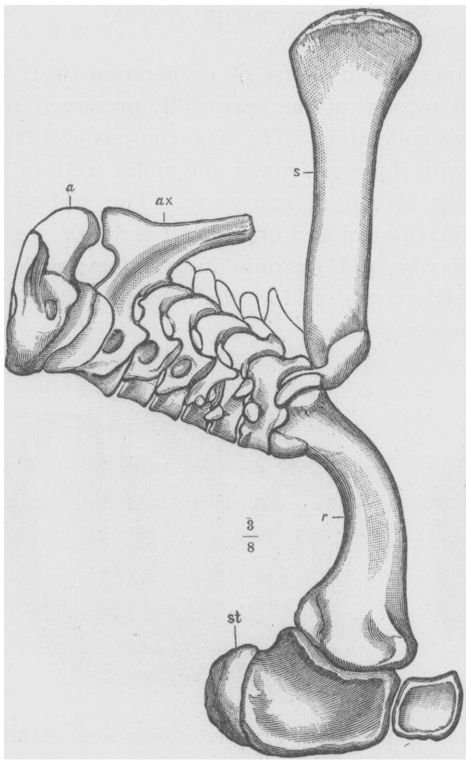


Fig. 27. Side view of cervical and first dorsal vertebræ, together with first rib and sturnum of *Stylinodon mirus*: *a.*, atlas; *ax.*, axis; *s.*, spine of first dorsal; *r.*, first rib; *st.*, sturnum. (After Marsh.)

there are seven teeth behind the large scalpriform canine, whose root is extended backward as far as the base of the penultimate molar. The condyle of the jaw is transverse, and its motion was not limited behind by a postglenoid process. The body of the jaw is remarkably short and deep, as is also the *symphysis mandibuli*. The skull is short and massive, without prominent sagittal crest, and having the arrangement of the occipital plane similar to some of the later Edentates. The occipital condyles are small, and there are no distinct paroccipital processes.

In the cervical vertebræ (Figs. 27 and 28) the centra are short, with nearly flat articular faces. The axis has a long neural spine directed backward. The neural spine of the first dorsal is elongated, as are those of the succeeding anterior dorsals. None of the cervicals show a double interlocking, such as is seen in many of the later Edentates.

In the shoulder girdle the scapula is relatively long and narrow, with prominent acromion, which supported a well-developed clavicle. The coracoid is small. The humerus (Fig. 29) is short and stout; the head displays the pyriform pattern so highly characteristic of the Edentata; the deltoid crest is powerful, and there is a distinct entepicondylar foramen. The ulna and radius (Fig. 30) are almost identical in all their features with these bones in *Hemiganus*, *Psittacotherium* and *Calamodon*. The manus, moreover, shows all the characters above described in *Psittacotherium*. No terminal phalanges are known, but the similarity of the rest of the foot with that of *Psittacotherium* is so striking that there can be no doubt of the fact that *Stylinodon* possessed large, powerful claws.

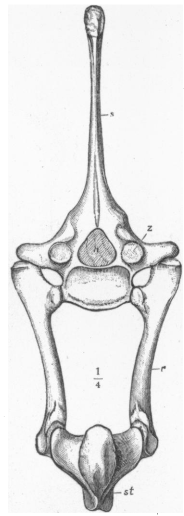


Fig. 28. Cross section of thorax, front view, of *Stylinodon mirus*. Lettering as in last figure. (After Marsh.)

Family CONORYCTIDÆ.

In this family I arrange two genera, *viz.*: *Conoryctes* and *Onychodectes*. The family distinctions between them and the Stylinodontidæ are not great, more particularly when compared with the earliest representative of this family, *Hemiganus*. The following important differences, however, may be noted: In the Stylinodontidæ the long axis of the second and third premolars in the lower jaw is placed transversely to the long axis of the jaw, and, as already described, these teeth develop two cusps which stand in this position. The fourth lower premolar, on the other hand,

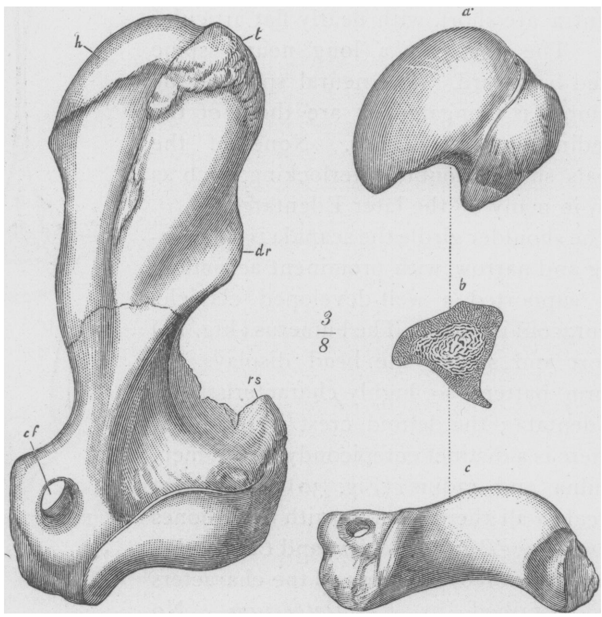


Fig. 29. Front, proximal, distal and sectional views of humerus of *Stylinodon mirus*: *h.*, head; *t.*, tuberosity; *dr.*, deltoid ridge; *ef.*, entepicondylar foramen; *rs.*, supinator ridge. (After Marsh.)

developed a posterior heel and became submolariform, quite in the ordinary way. In the Conoryctidæ the second and third lower premolars show no disposition to develop this peculiar bilobed condition, but the long axis of the tooth agrees with that of the jaw. These differences are no doubt dependent upon the length of the jaws in the respective groups, which, together with their concomitant modifications, may be taken to define the families. We thus note that the lower jaw in the Conoryctidæ is comparatively long and slender, lacking the deep, massive appearance of the Stylinodontidæ; the coronoid is not so much enlarged, and the posterior temination of the tooth line does not pass behind the anterior border of the coronoid. The condyle, moreover, is placed more nearly on a level with the tooth line. The propriety of associating the two groups in one suborder is apparent when the identity of the pattern of the molar crowns is considered, and what is yet probably more significant, the loss of incisors and the weak development of the enamel upon all the teeth.

Onychodectes[1] *Cope.*

So far this genus has been found in the lower beds of the Puerco only. It is represented by two species, *S. tissonensis* Cope, and *O. rarus* Osborn & Earle. The first of these species is not uncommon in the collection of the Museum, and is represented by nearly every part of the skeleton, while the second is known from a single fragment of a lower jaw.

In *O. tissonensis* the skull is long and narrow (Fig. 31), with a weak development of the sagittal crest. There is no indication of postorbital processes on the frontals. The muzzle is unusually long and slender, being well roofed by the nasals, which extend forwards in such a manner as to cover in the premaxillæ almost completely above. The premaxillaries are of considerable size, and extend well back between the nasals and the maxillaries above. The palate is long and narrow, and there is no evidence that it was very much prolonged behind the termination of the molar tooth line. The foramina of the skull cannot be determined, on account of the intensely hard matrix in which it is imbedded.

The lower jaw (Fig. 32) is long and comparatively slender; the coronoid is high and falcate, the condyle is placed just above the level of the

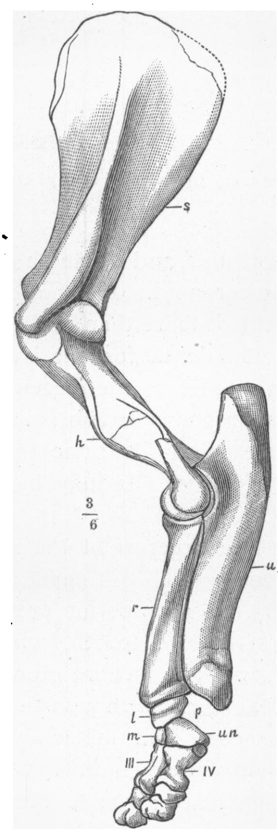


Fig. 30. Left fore limb of *Stylinodon mirus*: *s.*, scapula; *h.*, humerus; *r.*, radius; *u.*, ulna; *l.*, lunar; *un.*, unciform; *m.*, magnum. (After Marsh.)

[1] Proc. Amer. Philos. Soc., July 20, 1888, p 317.

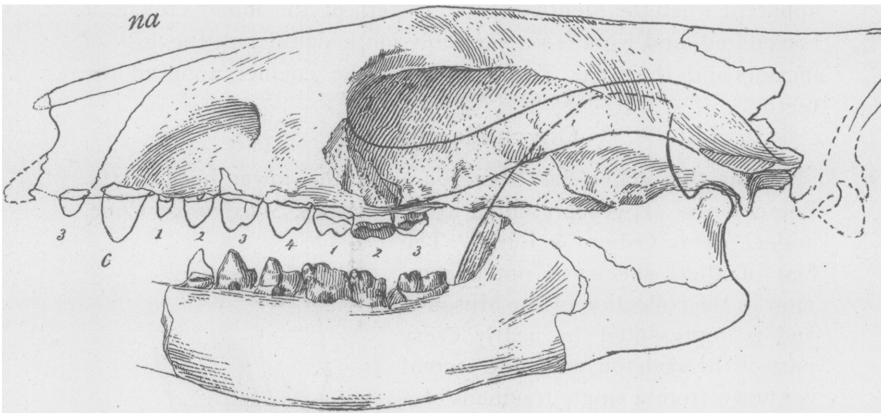


Fig. 31. Side view of skull of *Onychodectes tissonensis*. Natural size. (After Osborn and Earle.)

tooth line, and the teeth do not pass behind the anterior border of the coronoid. It is not clear whether the angle is well developed, but it is more than probable that it is.

The dental formula is somewhat in doubt, owing to our lack of knowledge of the incisors; that there was one pair at least in the upper jaw is certain, and I think it more than likely that there were two. The same uncertainty prevails with reference to the lower jaw. It may be provisionally written I.$\frac{2}{2}$(?), C.$\frac{1}{1}$, Pm.$\frac{4}{4}$, M.$\frac{3}{3}$.

The structure of the teeth (Fig. 33) has been well described by Cope, and I will mention here only their more salient characters. The superior premolars are all simple, with the exception of the fourth, which has a strong external and internal cusp. The unworn crowns of the upper molars show three principal cusps, with a weak external cingulum. The two outer cusps, paracone and metacone are subequal, and their summits are slightly inclined inwards, giving to them a somewhat claw-like appearance: hence the name *Onychodectes* (claw biter). The internal cusp or protocone is large and lunate, having upon the limbs of the crescent faint intermediate cusps. The inner face of the crown is remarkably deep, and the enamel has unusual vertical extent.

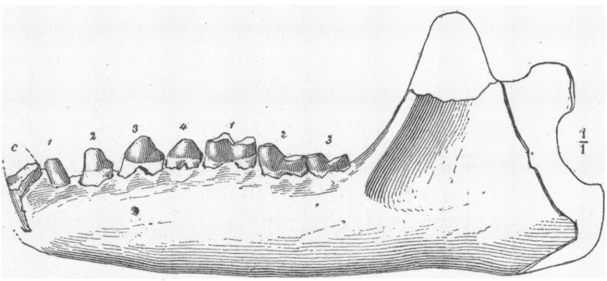


Fig. 32.

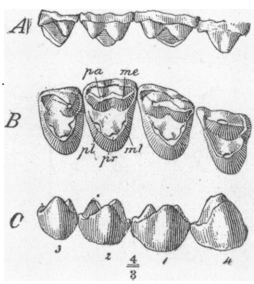
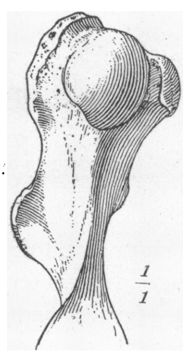


Fig. 33.



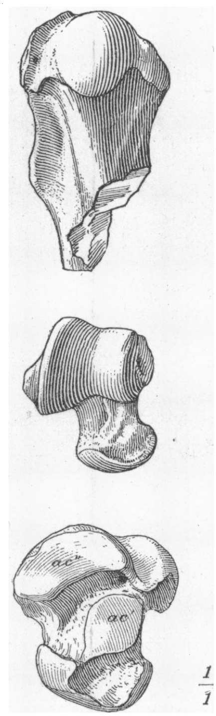


Fig. 35. Fig. 34.

Fig. 32. Side view of lower jaw of *Onychodectes tissonensis.* (From Osborn and Scott's forthcoming book.)

Fig. 33. Crown (*B*), outside (*A*), and inside (*C*) views of upper molars and fourth premolar of *Onychodectes tissonensis : pa* , paracone ; *me.*, metacone ; *ml.*, metaconule ; *pr.*, protocone ; *pl.*, protoconule. (From Osborn and Scott's forthcoming book.)

Fig. 34. Posterior view of head of humerus, and dorsal and plantar views of astragalus of *Onychodectes tissonensis.*

Fig. 35. Posterior view of the head of the humerus of a modern Armadillo (*Tatusia*).

The premolars of the inferior series are simple, laterally compressed cones, except the third, which has a faint posterior heel, and the fourth, which has a broader and better developed heel. The pattern of the molars are of the imperfect tuberculo-sectorial type, the anterior cusp of the trigon being poorly developed. The two principal cusps of the trigon are subequal, and are placed in such a manner as to occupy a transverse position. The

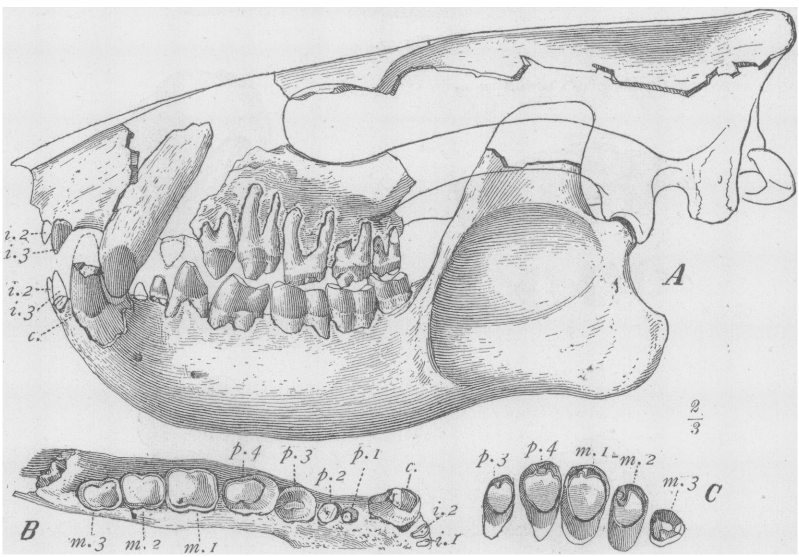


Fig. 36. Side view of skull (*A*), crown view of lower teeth (*B*), and crown view of upper teeth (*C*), of *Conoryctes comma*. (From Osborn and Scott's forthcoming book.)

heel is broad and lunate, and in the unworn condition carries three principal cusps and a small though distinct cusp at its anterior inner termination. The great development of this element in one specimen has led Osborn and Earle to establish a second species, *O. rarus*.

Numerous fragments of the skeleton are preserved, from which it is possible to obtain some idea of its structure. In one specimen (No. 3576*a*) there is a portion of a humerus (Fig. 34) with a complete proximal extremity. The head of the bone displays that characteristic pyriform articular surface so constant in all the Edentates; in the arrangements of the tuberosities and the deltoid crests it resembles the corresponding parts of the Armadillo (Fig. 35).

A number of metapodials of both the fore and hind feet show that these bones are moderately short and stout, while the phalanges are more elongated and slender than those of *Hemiganus*. The claw has essentially the same shape, but is relatively much smaller. The astragalus (Fig. 34) has a well-grooved trochlear surface, and can be readily distinguished from its cotemporaries by the absence of the astragalar foramen.

Conoryctes[1] *Cope.*

Remains of this genus are not uncommon in the upper horizon of the Puerco, in which it has been found exclusively so far. These remains are all referable to a single species, *C. comma.* Parts of the skull and jaws are known, together with a few fragments of limb bones, but further than this our knowledge of this form leaves much to be desired.

In the skull (Fig. 36) the facial portion is much shorter than in *Onychodectes*, and the sagittal crest is not conspicuous. The lower jaw is moderately short and stout, the coronoid is not especially enlarged, and the condyle, as in *Onychodectes*, is placed near the level of the tooth line. The lower molars do not pass behind the anterior border of the coronoid, and the angle is well developed.

The dental formula is I.$\frac{2}{2}$, C.$\frac{1}{1}$, Pm.$\frac{3}{4}$, M.$\frac{3}{3}$. The incisors are small and pointed, and are separated from the canines in the upper jaw by a considerable diastema. The canines are of good size and probably had completely enamel-covered crowns, although in all the specimens known the enamel is removed from certain areas of these teeth ; whether this is the result of wear, or whether it is absent in these situations, is impossible to say : at all events the enamel covering of these teeth, as in all the others of this species, is conspicuous for its general thinness and weak development.

The first (second) superior premolar is simple, and follows the canine with but comparatively little interval ; the second (third)

[1] Proc. Amer. Philos. Soc., 1881, p. 486.

premolar is trilobed, having a large external conical cusp, and a small somewhat lunate inner with a small anterior basal cusp. The fourth premolar is tritubercular, and is almost, if not quite, molariform in structure. In nearly all the specimens the crowns of the molars are so much worn as to obscure greatly, if not to destroy completely, the crown pattern ; this, moreover, occurred early in the life of the individual, and in some instances, before all the teeth were fully erupted. In some of the specimens the crown (Fig. 36) is sufficiently preserved to indicate that it was tritubercular, having two external and one internal cusp. All the molars show their tendency toward hypsodonty in the great vertical extent of the enamel upon their inner or lingual faces.

In the lower jaw all the premolars, with the exception of the fourth, are simple laterally compressed cones. This latter tooth has a principal anterior cusp, to which is added a prominent basin-shaped heel ; when the crown is reduced by wear it resembles a true molar closely, and is generally spoken of as molariform. The structure of the crowns of the inferior molars, while in no instance well preserved, yet indicate that the usual elements of the trigon are present ; the anterior element is, however, very small and insignificant, and can be said to be practically absent. The two posterior cusps of the trigon are subequal and placed in such a manner that upon wear they present the appearance of a transverse crest. The heel is large and prominent, and when little worn shows a distinct basin shape. In size the first molar is the largest and the last is the smallest.

Among the fragments of limb bones, a head of a humerus exhibits the same characteristic pattern already noted in the other members of the group.

Altogether this genus shows in some respects resemblances to *Hemiganus*, and in others is close to *Onychodectes*. The terminal phalanges, as well as the rest of the foot-structure, are entirely unknown.

Relationship to the Edentata.

Considering the Ganodonta as a whole, there can be but little doubt that they form a homogeneous group, characterized by certain features which became more and more marked as the respective phyla advanced into later time. These features relate to the loss of the incisors, the weak development and loss of enamel, and the development of hypsodonty with its dependent modification, growth from a persistent pulp. They are further united by the great similarity in pattern of the molar crowns, and the characteristic shape of the head of the humerus. All these characters go to indicate that, however widely they may have been separated at the beginning of the Puerco, they are, nevertheless, descended from a common ancestor in the earlier Mesozoic.

One phylum, *viz.:* the Stylinodontidæ, as I have attempted to show, began in the generalized type *Hemiganus*, and continued into the Bridger, terminating, so far at least as our positive knowledge now extends, in *Stylinodon.* This, it may be remarked, is as complete and perfect a phylum as has ever been deciphered within the whole range of palæontology. Whether or not *Conoryctes* or *Onychodectes* left modified descendants is uncertain, but it is not impossible that some of the later Edentata may yet be traced to them.

Regarding the Edentate affinities of at least one of these groups, the evidence, in my judgment, is so overwhelmingly conclusive, that a mere statement of the points of likeness will suffice : I refer particularly to the Stylinodont phylum in its relations to the great Ground Sloths or Gravigrada. These characters are as follows : (1) In the skull there is great similarity in form ; the muzzle is short, the sagittal crest is low, and the occipital plane slopes forwards as in *Mylodon*, *Megatherium* and *Megalonyx.* (2) The lower jaw is short, deep and robust, with a greatly enlarged coronoid, a prominent angle, and a position of the condyle high above the tooth line. (3) The incisors are reduced to a single pair in the lower jaw of *Calamodon*, and are probably completely absent in *Stylinodon.* (4) The posterior portion of the tooth line below passes well behind the anterior border of the coronoid. (5) The canines in all are enlarged, and in *Calamodon* and *Stylinodon* grew from persistent pulps, as in *Megalonyx.* (6) All the molars and premolars in *Stylinodon* are greatly elongated, of persistent growth, and the enamel is confined to narrow vertical bands. (7) There is a thick deposit of cementum on the dentine in those situations in which the enamel disappears. (8) The cervical vertebræ strongly resemble those of the Gravigrada. (9) There were well-developed clavicles present. (10) The humerus bears a striking resemblance in all of its essential features to those of *Mylodon*, *Megalonyx* and *Megatherium*. (11) The ulna and radius are also similar. (12) The manus is almost identical with that of the Ground Sloths. (13) The humerus and ulna and radius have no medullary cavities; and (14) the femur has all the characteristic features of the Gravigrada. (15) The lumbar vertebral formula was the same as in the Edentata. (16) The pelvis is decidedly Edentate; and (17) the caudals bear a striking resemblance to those of the Ground Sloths.

If this astonishing array of similarities is accidental and does not indicate genetic affinity, then all that can be said is that palæontological evidence is worthless in the determination of the various successive steps in the descent of a group or species. I hold that, in view of all the evidence above set forth, the proposition that the one has descended from the other may now be regarded as a positively demonstrated fact.

If this proposition be true, then it follows that all the South American Edentates must have been derived from the North American Ganodonta, since their earliest appearance in South America does not antedate the Santa Cruz epoch. In this formation they appear suddenly in great numbers and variety without apparently any previous announcement in the older Pyrotherium deposits. This fact in itself would seem to indicate that they were migrants from another region, and while we are as yet unable to place these deposits in the time scale with accuracy, it is yet highly probable that the Santa Cruz Beds are not older than our North American Oligocene. In North America, as I have just shown, the Ganodonta appear in the very earliest Puerco deposits, and continue without interruption into the Bridger, where they disappear. No evidences of them have up to date been detected in the Uinta or White River Beds.

Now it is currently believed by geologists that no land connections existed between North and South America from the close of the Cretaceous to the close of the Miocene, when an extensive land bridge was formed. I am not familiar with the geological evidence upon which this conclusion rests, but if one is permitted to judge from the subjoined statement of Mr. F. C. Nicholas,[1] it is at the very least open to question. It is of course possible that the Ganodonta may have reached South America by way of Europe, Africa and Antartica, but on the whole it seems infinitely more probable that there was a land bridge of short duration during Eocene time between North and South America, and that they reached their destination in this way, than by the questionable and circuitous route just mentioned. If they gained entrance into South America by the European-African route, it seems indeed strange that they should have left no remains in the later Tertiaries of Europe. With the exception of a single specimen of *Calamodan europæus*, from deposits corresponding with the Wasatch in age, all traces of the American Edentata are absent in Europe, Asia and Africa.

ORIGIN OF THE EDENTATA.

In my first paper[2] I endeavored to establish the fact that there is a group of forms occurring in our Eocene deposits which show a remarkable resemblance to the Edentata, and which, accord-

[1] In a letter to me under date of Feb. 12, 1897, Mr. Nicholas writes as follows:

"While traveling through Central America I have noticed that certain parts of it appear to be of rather the older than the more recent geological periods. On the coast of Spanish Honduras I found float material containing *Spirifer*, apparently *S. mucronatus*.

"In the same country I found residual clays where the surface erosions indicate an old formation. Along the coast there are immense alluvial deposits that must have taken a long time to accumulate. In the interior I find sedimentary formations and intrusive plagioclase rocks.

"Along the Pacific the country is of volcanic formation. On the Isthmus of Panama there are sedimentary rocks and cemented gravels resembling somewhat the terrace formation of the Atlantic.

"In the central parts of the Isthmus there are plagioclase rocks and crystalline types.

"To the south, below the Gulf of Darien, there are low sediments which, except for a short divide, are continuous from the Atlantic to the Pacific. The divide has evidently been intruded through the sediments, because they are found irregularly over it.

"The continents must have been separated at this point, the geological age being undetermined, but judging from the erosions and by comparisons of various intrusions in the district, I should say it was of early Tertiary formation.

"I feel certain that parts of Central America belong to the Devonian Period, that before Cretaceous times these parts of the country were ancient islands. In Cretaceous and early Tertiary times seismic disturbances must have been very great, and subsidences separating the two continents for irregular periods would be probable; but the older, that is, the least central parts of Central America, were comparatively undisturbed. Here animals forced south by adverse conditions further north would have found a resting place, and the Sloths, Armadillos, Anteaters, and similar types, are very abundant.

"These secure parts of the country were very near the Isthmus, and when the changing conditions were favorable, animals could have easily made their way to South America and then overrun the country, developing most abundantly in the lower latitudes, where conditions were most favorable to them."

[2] Bull. Amer. Mus. Nat. Hist., Vol. VIII, p. 259–262, Nov. 30, 1896; Science, Dec. 11, 1896, p. 865.

ing to our present knowledge, must be regarded as their ancestors. This group I have defined and named the Ganodonta, and referred it, as a suborder, to the Edentata, enumerating at the same time the genera, so far known, of which it is composed, as well as their distinctions. In this I have clearly been the first, since no previous effort of the kind had ever before been made. It is true that both Marsh and Cope have *suggested* the possibility of its truth, but it is equally true that their knowledge of the composition, limitation and affinities of the group have, previous to the appearance of my paper, been indeed vague. Marsh, in his Nashville address, speaking of the Tillodontia, said: "and possibly we may here yet find the key to the Edentate genealogy." He does not say that it *has* been found, or that it *has* been demonstrated, or that any one has even *attempted* to demonstrate such a proposition; he merely contents himself with the statement of the possibility that it *may yet be* found here. From this I conclude that the origin of the Edentata was unknown to him at that time. He also failed to recognize the distinctions between the Ganodonta and the Tillodontia.

Cope at one time held that his group Tæniodonta exhibits affinities with the Edentata, but this he subsequently abandoned, and he, too, utterly failed to grasp the fundamental facts of the problem. This is amply attested by his classification of *Hemiganus*, *Onychodectes* and *Conoryctes* in the Creodonta, by his placing *Psittacotherium* in the Tillodontia, and by his failure to recognize the intimate relationship between *Calamodon* and *Stylinodon.*

I hold that a proposition is not demonstrated until the facts are adduced necessary for its proof, and a mere suggestion falls a long way short of this.

As regards the name of the suborder, it is necessary to add a few words. Cope employed the name Tæniodonta to designate a supposed suborder of his group Bunotheria, in which he placed[1] the Creodonta, Mesodonta, Insectivora, Tillodontia and Tæniodonta. In the Tæniodonta he classified two genera, *viz.*, *Calamodon* and *Ectoganus;* he defined the suborder as follows: "Incisors much enlarged, growing from persistent pulps, the superior with enamel in anterior and posterior bands, and hence truncate."

[1] Tertiary Vertebrata, p. 185.

Now I do not know of any specimens in any collection which can be determined with certainty as being either canines or incisors of the superior dentition of either of these genera. I judge from Prof. Cope's figures[1] that the tooth which he took for a superior incisor is an unworn second lower premolar. I know the superior incisors and canines of *Psittacotherium*, and in this genus the enamel does *not* occur in anterior and posterior bands; if one can judge by the near relationship existing between *Psittacotherium* and *Calamodon*, it is almost, if not quite, certain that this latter genus had the enamel of these teeth distributed in the same manner. It will thus be seen that this definition is conceived in error, and does not define any known group. The name cannot, therefore, be used.

Since the appearance of my first paper, Prof. Marsh in his description of *Stylinodon mirus*, has substituted the name Stylinodontia for Ganodonta, on the ground that the name Ganodonta is preoccupied. The name *Ganodus* was used by Egerton in 1843 for a genus of fishes. Now if a generic name can preoccupy an ordinal or subordinal name, then Prof. Marsh's name Stylinodontia is open to the same objection, since it is preoccupied by the generic name *Stylinodon*, and the ordinal term Dinocerata is preoccupied by *Dinoceras*, etc. As a matter of fact, according to the best authorities on zoölogical nomenclature, the use of a name in a generic sense does not preclude its use in a family, subordinal or ordinal sense; the termination is different in each case, and there is not the slightest difficulty or question as to what is meant. I therefore contend that the name Ganodonta is a valid one; that it is the first that was ever employed to designate the group of animals to which it was applied, and that according to all usages and customs of naturalists in the employment of names it must stand.

In the present imperfect state of our knowledge it is quite impossible to frame a comprehensive definition of the order Edentata, if it is admitted that they are descended from the Ganodonta, and are genetically related to them. In the order Edentata I include only the American forms, since it is probable that the Old World Edentates have had a different origin,

[1] U. S. Geol. Surv. W. 100th M., Pl. XLI.

although it is not impossible that they may have originated from a common source. The definition of the more modern forms has always rested upon the loss of the enamel of the teeth and the complication of the vertebral articulations. As already seen, the Ganodonta violate both these characters, but they are none the less members of the same group, if it can once be established that they are related by ties of consanguinity. It is idle to speak of "essential" and "adaptive characters." If evolution be a fact, then *all* characters which distinguish one group of animals from another must ultimately disappear as we approach the point of their common origin. This is strikingly illustrated in this same group Ganodonta, the earlier members of which are separated by a comparatively small interval from the contemporaneous Creodonta, Condylarthra and other groups. If our definitions mean anything, and are to be of any real service, they can only record the characters which the various phyla have acquired in point of modification, and express the tendencies whither these modifications, however small and inconspicuous they may be in their beginning, ultimately lead. The single character, therefore, which is common to all the forms of this group, thus comprehensively included, is an early disposition to the loss of the enamel from the crowns of the teeth, as well as the loss of incisors from both jaws. This I take it, in the absence of more exact knowledge, is the real definition of Edentata.

Order EDENTATA.

I have defined the Ganodonta as follows: "Primitive Edentates, characterized in the earlier forms by rooted teeth with divided fangs, with their crowns having a more or less complete enamel investment, in the later forms by the teeth becoming hypsodont, rootless, of persistent growth, and by limitation of the enamel to vertical bands in progressive decrease. They are further characterized by the presence of incisors in both jaws, by a typical molar and premolar dentition, by a trituberculate molar crown, which disappears early in life through wear, leaving the dentine exposed."

I further add that the vertebral articulations are not complex and hence nomarthrous.

If we limit the order Edentata to the American forms alone, then it is divisible into two suborders, viz.: Ganodonta and Xenarthra, but if we include the Old World forms, another sub-order, Nomarthra, must be added.

The definitions of these three suborders would be as follows:

Teeth more or less covered with enamel; one or two pairs of incisors present; vertebral articulations not complex.... GANODONTA Wortman.

Teeth without enamel investment; incisors rarely present; vertebral articulations complex.............................XENARTHRA Gill.

Teeth without enamel investment; incisors absent; vertebral articulations not complex...............................NOMARTHRA Gill.

The two known families of the Ganodonta may be defined thus:

Long axis of the second and third lower premolars longitudinal......
CONORYCTIDÆ.

Long axis of the second and third premolars transverse....STYLINODONTIDÆ.

The two genera of the Conoryctidæ are distinguished as follows:

Premolars $\frac{3}{4}$..*Conoryctes*.
Premolars $\frac{4}{4}$ ....*Onychodectes*.

The genera of the Stylinodontidæ are:

Crowns of upper canines encased in enamel; canines not growing from persistent pulps; lower incisors faced with enamel; lower molars and premolars rooted, with divided fangs, and enamel-covered crown..........................*Hemiganus* Cope. Lower Puerco.

Crowns of upper canines with enamel confined to anterior face; canines not growing from persistent pulps; lower incisors surrounded with enamel; lower molars and premolars rooted, with fangs connate, and enamel-covered crowns .. ..
Psittacotherium Cope. Upper Puerco.

Crowns of superior canines with enamel confined to anterior face; canines growing from persistent pulps; lower incisors without enamel; lower molars and premolars with connate fangs; enamel confined to vertical bands on inferior premolars.................
Calamodon Cope. Wasatch.

Crowns of canines unknown, growing from persistent pulps; all lower teeth rootless, growing from persistent pulps; enamel of all lower molars and premolars confined to vertical narrow bands.........
Stylinodon Marsh. Bridger and Wind River.